Survivability

- Crash Forces
- Occupiable Space
- Post-Crash

Crash Forces

- Human tolerance - up to 50 G's without potentially fatal injury
- Methods of calculating
  - Physics/mathematical means
  - Assessing structural condition of aircraft
  - Assessing injuries of the occupants

Mathematical Means

- **Uses aircraft's estimated speed and impact angle along with stopping and crush distances measured from the wreckage and crash site. Using equations of motion and assuming a reasonable simplified crash impulse shape, the data can be used to estimate the peak crash forces applied to the center of gravity of the aircraft**

- **Many assumptions involved in computation and result is a ballpark estimate**

Mathematical Means

- **Peak G forces can differ by a factor of two depending on the impulse shape chosen for the crash forces calculations**

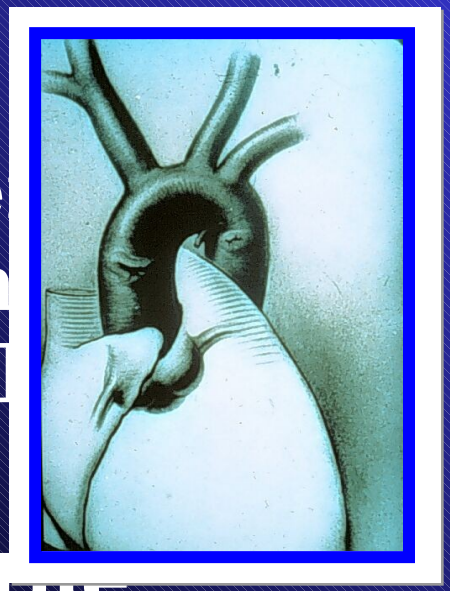
Condition of the Aircraft

Aircraft relatively intact - in general indicates <u>overall</u> crash forces low and within the limits of human

Condition of the Aircraft

- Extensive disruption of aircraft - usually means high G forces
  - When crash forces exceed human tolerance the wreckage is often reduced to an assortment of variable sized portions of generic aircraft fragments
- Somewhat crude estimation

- **Thoracic aortic lacerations**
  - **Probably the best docu- me of the physical injuries wh are corre- lated with cras forces.**
  - **Decelerative forces stretch the aorta and generate stresses which are greatest in the fixed portions. At a threshold level of stress the aorta tears.**



Condition of the Occupants

- **Thoracic aortic lacerations**
  - **Intimal tears at about 50 G's**
  - **Complete transection about 80 to 100 Gs**
  - **Presence of rib fractures limits the use of this estimation**

- **Vertebral column**
  - **Compression fractures at 20 to 30 Gs in Gz axis**
  - **Fracture dislocations and 2nd vertebrae at 20 to 40 Gs with appropriate rotational components**
  - **Thoracic and abdominal vertebral body transections at 200 to 300 Gs**

Decelerative Injuries

- Pelvic fractures through pelvic bones (not diastasis of symphysis) at 100-200 Gs
- Extensive body fragmentation at 350 Gs and above

These ballpark estimates of crash forces should define the same ballpark for a given accident. If there is a significant divergence between the three (mathematical calculations, assessment of aircraft and occupants), there is some dynamic element of the mishap sequence that must be identified through further investigation.

Occupiable Space

- **Even if general crash forces are survivable, occupants must have adequate space available during entire crash sequence. In a contest between an occupant and components of the aircraft for space, massive forces can be exchanged and the occupant often loses with serious or fatal injuries. This is the mechanism of many of the blunt force injuries sustained by mishap victims.**

Occupiable Space

- **Wreckage**
  - –Aircraft structures have plasticity
  - –“Witness marks”
- **Correlation of documented injuries with wreckage occupiable space and “witness marks”**

Post-Crash Environment

- If crash forces and occupiable space within human tolerance, survival requires successful escape from the aircraft by either active or passive means
- Fire, water hazards are main hazards
- Measures such as crash worthy fuel systems and water survival training aimed at prevention of these hazards.

Injury Analysis

Intrusive Injuries

- Rotor or propeller blades
- Trees or wi
- Missiles
- Other aircr
  structur

–Basilar skull fractures

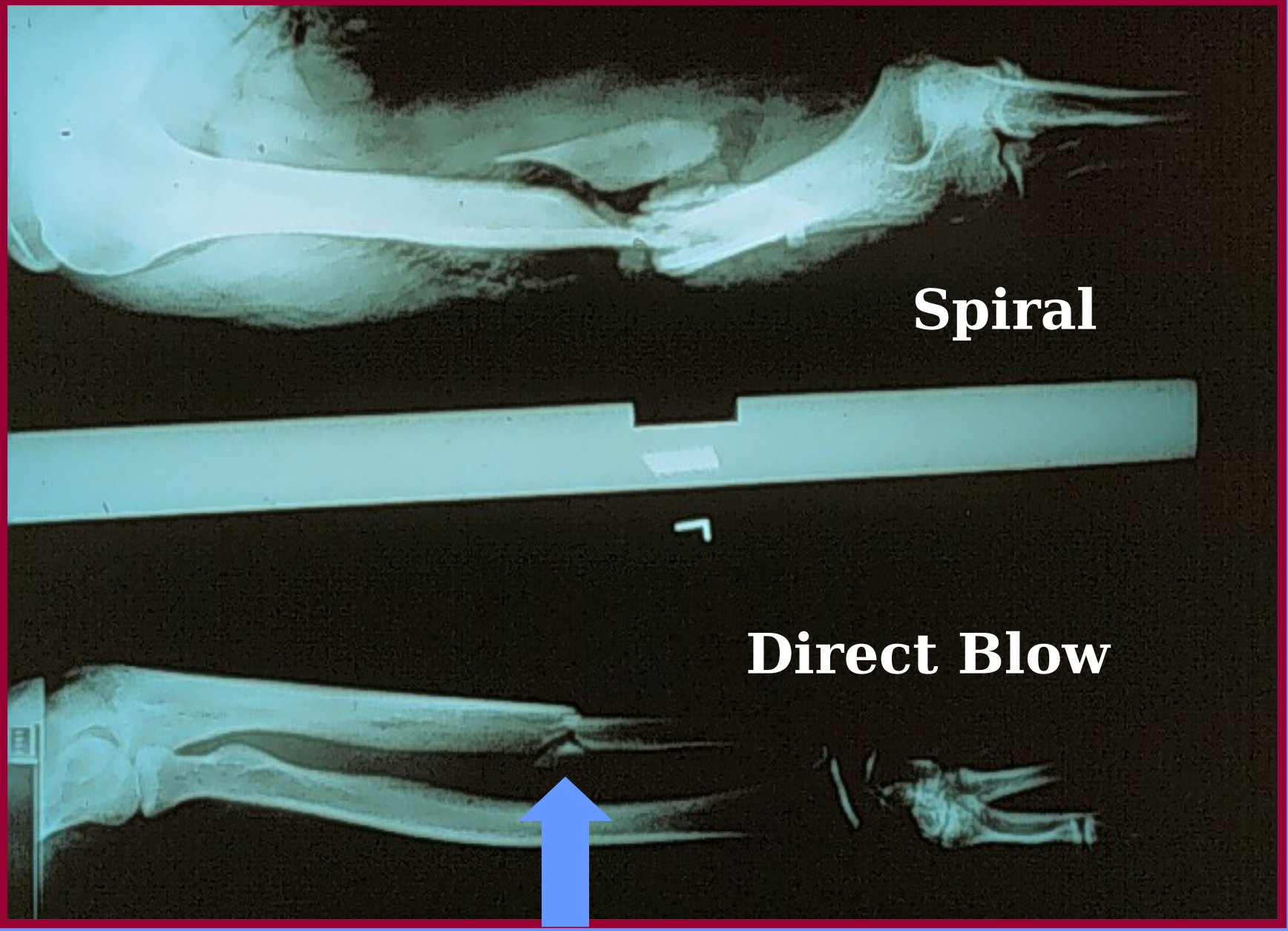
- Impact of chin against control panel, stick, or cyclic
- Force transmitted to base of skull
- Better restraint systems have significantly reduced the frequency of such injuries in helicopter mishaps

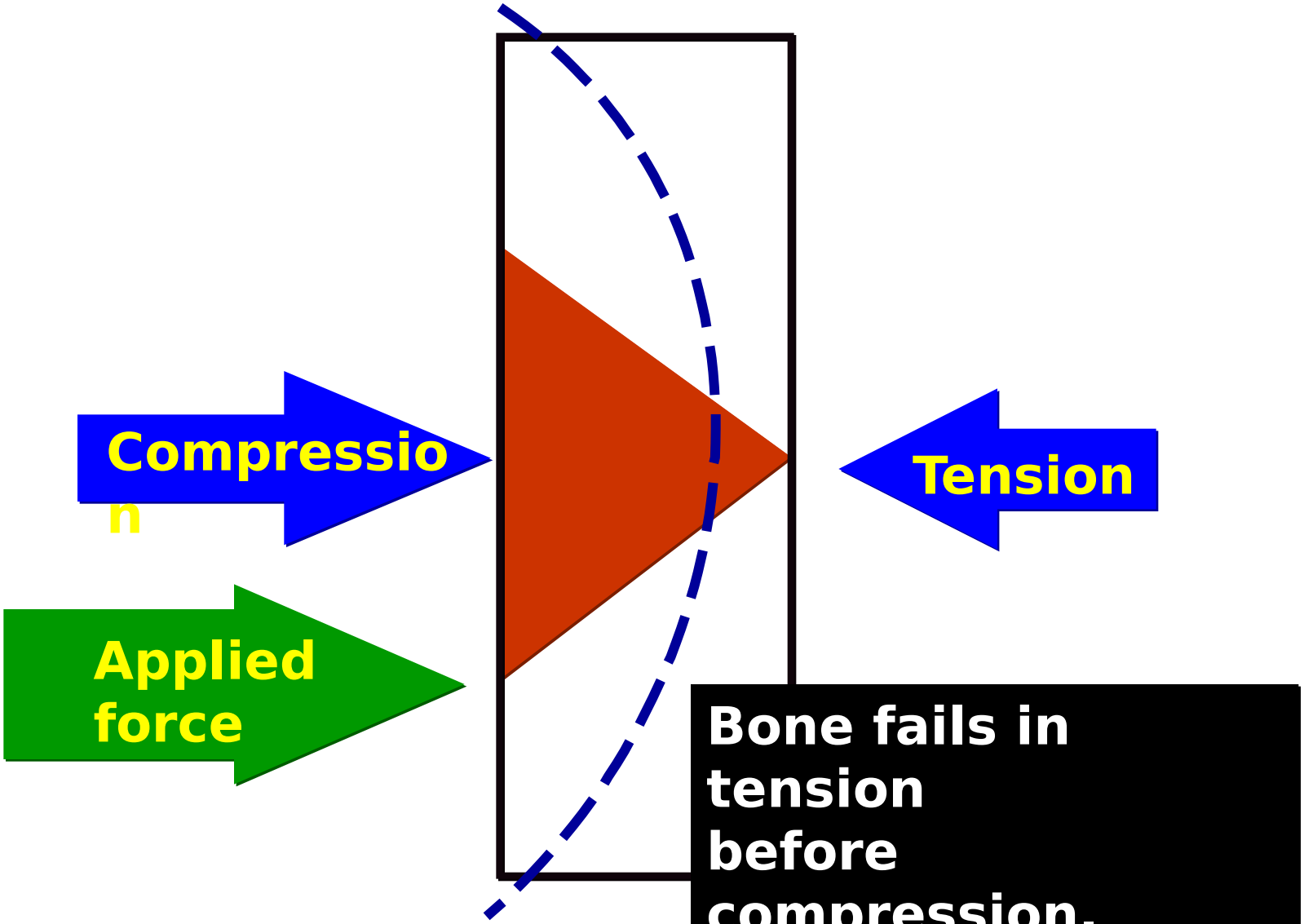
Injury Patterns

- **Basilar Skull fracture with chin abrasion**
- **Control injuries**
- **Drowning**

Extremity Fractures

- Radiographs excellent means for determining mechanism of fractures of long bones
  - Spiral fractures - twisting
  - Triangular fracture - direct blow with triangle pointing in direction of applied force
  - Compression fractures


Spiral
Direct Blow


Compressio
n
Tension
Applied
force
Bone fails in
tension
before
compression.
Initial fracture
propagated from
tension to

Pattern Injury Analysis

- **Patterned Injuries**
  - –Characteristic morphology which correlates with mechanism of injury.
  - –Demonstrate characteristics of the object that was interacting forcefully with the occupant
  - –Spectrum of specificity

Blunt Force Injuries

- **Patterned injuries can provide valuable information**
  - **Place the individual in contact with another object**
  - **Preserve indication of the state of objects**

Fire Related Deaths

Alive in Fire?

- Soot in airway
- Increased carbon monoxide
- Inhalation injuries

Cyanide

- Somewhat controversial
- Produces by burning plastics, insulation, etc.

Fire Artifacts

- “Pugilistic” posture
- Skin splits
- Absence of distal extremities
- Heat fractures
- Epidural hemorrhage
- Burning away of chest or abdominal wall

Flash Burns

- Fireballs associated with explosions of vaporized combustibles such as fuel and hydraulics.
  - Affect skin surfaces directly exposed to the brief thermal pulse.
  - Patterned burns with relatively unburned areas on areas not exposed.
  - Informative about position of occupant at time of explosion.